Coal Pipe Balance and LOI

Presented by Rick Wark
President of Sure Alloy Steel

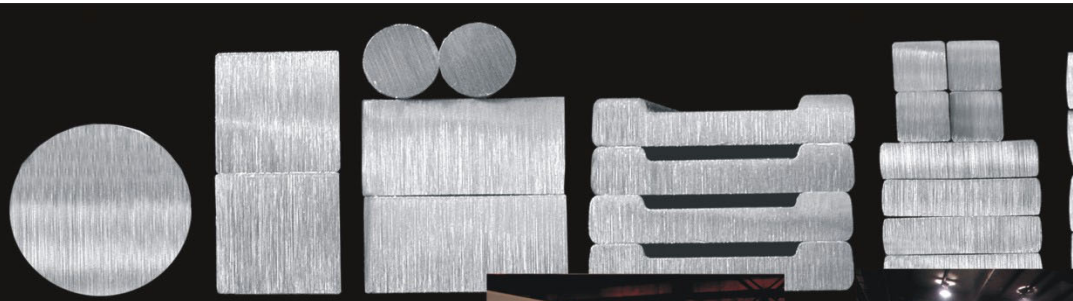
What does a Steel Company have to do with LOI ?

- We are more than just a Steel Company
- We have been in business for almost 60 years
- We have been doing work in the Power Industry for 25 years and have over 40 Patents
- We offer Engineering, Manufacturing, Fabricating, Installations, Testing, and Research

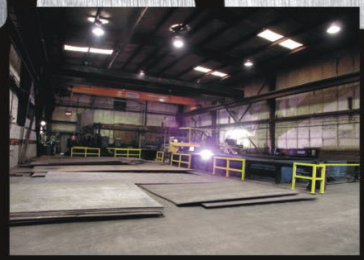
Sure Alloy Steel's Other Divisions

- **Cladtec-Is Our Weld Overlay Services and Thermal Spray Coatings Division**
- **Astech- Is an Alloy Steel Foundry which operates under common ownership**
- **Vtec- Is our ASME Pressure Vessel Facility capable of 500,000 Lb. Fabrications**

Sure Alloy Steel



SA 500 - SA 360/400 - SA 550 NM
SA 1750 CR - SA 1750 CRHT - SAS 380D
Hoghide Ceramic Patch Kits



Sure Alloy Steel's 76,000 sq. ft. Michigan facility is home to our fabricating shop and warehouse. Sure Alloy specializes in wear resistant steel and fabrications. We are equipped with technologically advanced fabricating equipment that is operated by experienced personnel. The success of Sure Alloy Steel is directly related to quality people, advanced design concepts, innovative engineering and progressive fabricating procedures. We consistently deliver quality solutions and performance.

Our engineers utilize Design-Cad to develop solutions, while advanced equipment, such as CNC cutting equipment will process each project to highest standards.

SURE ALLOY STEEL CORP.

Cladtec & Astech

CLADTEC

Cladtec, serves a large area of the country with it's two strategic locations. North in Madison Heights, Michigan and south in Longview, Texas.

Cladtec specializes in Total Wear Control. We rebuild worn out components with high wear material that will outlast new OEM components at a fraction of the cost.

We can repair worn components in-house or on-site. Cladtec crews are trained in all facets of on site procedures, including a comprehensive safety course. Our warehousing program of rebuilt components can save you money and assure you that your parts will be ready on-time for your immediate needs.

Cladtec uses the advanced Twin Wire Arc Spray technology to apply protective coatings to many industrial components and Power Plant Boilers. Cladtec can offer combinations of special alloys which produce highly abrasion and corrosion resistant coatings created thru Metamorphic Transformation Process.

ASTECH

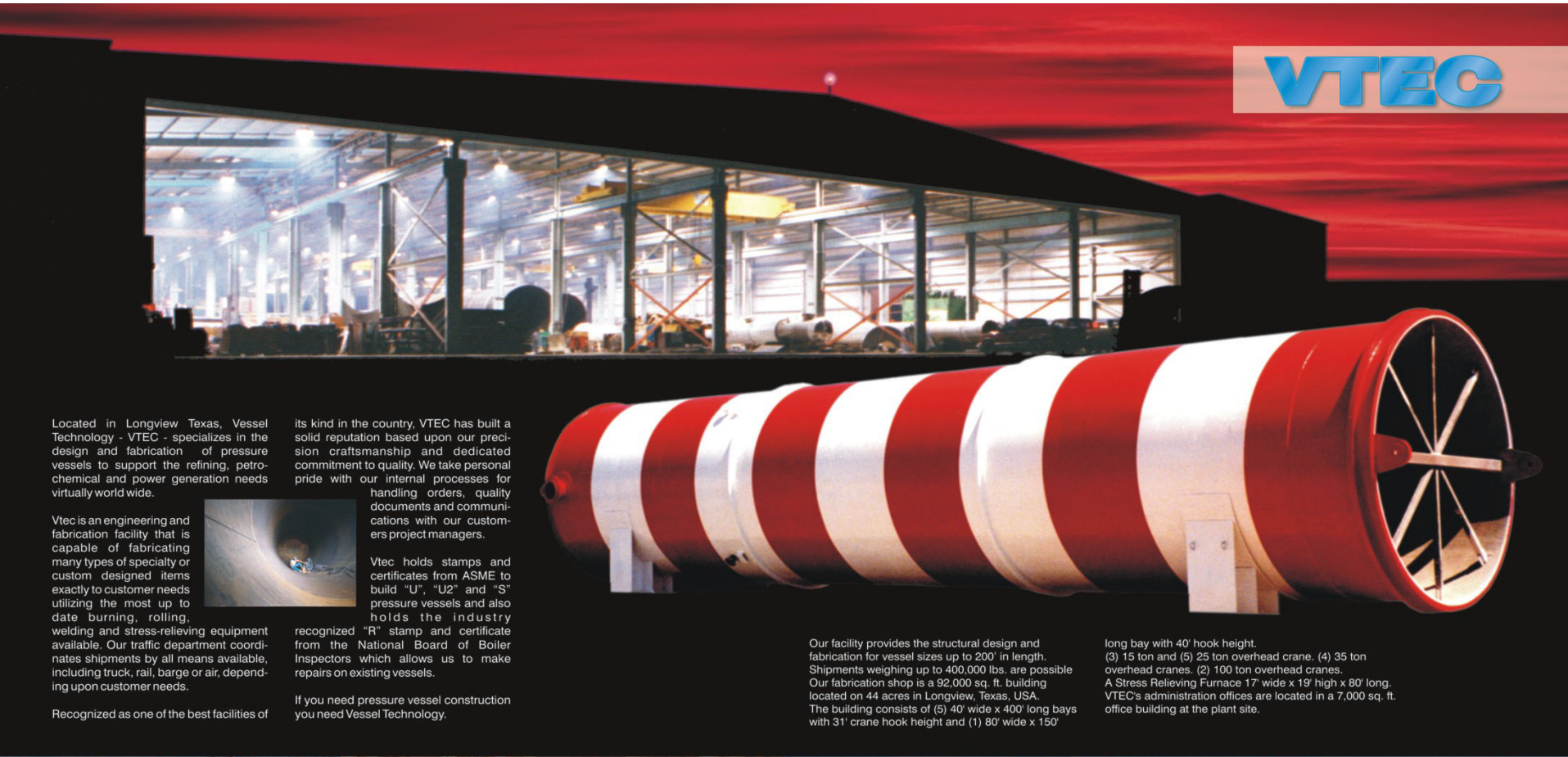
Astech, Inc. is a specialty steel jobbing foundry located in Vassar, MI. Our foundry is one of only a few specializing in the production of small and medium size alloy castings for wear, heat, and corrosion resistance. Our facility is unique with the capability for short and long casting runs tailored to meet industry requirements.

Astech draws upon a long history of experience in alloy grade steels and cast irons. Casting special alloys requires a special alliance of technology and expertise. Our customers require parts that perform well under extreme conditions and our technicians can formulate alloys to meet these individual needs.

Modern production equipment, which includes three 1000-pound induction furnaces, gives us the flexibility for quick turnarounds from one specialty alloy to the next. Our 45,000 sq. ft. facility and advanced data management capability can accommodate inventory programs and *just in-time* delivery.

Astech also offers several product lines which include shot blast replacement parts for blast cleaning machines and "tube cuffs" for boiler tube alignment.

VTEC



Located in Longview Texas, Vessel Technology - VTEC - specializes in the design and fabrication of pressure vessels to support the refining, petrochemical and power generation needs virtually world wide.

Vtec is an engineering and fabrication facility that is capable of fabricating many types of specialty or custom designed items exactly to customer needs utilizing the most up to date burning, rolling, welding and stress-relieving equipment available. Our traffic department coordinates shipments by all means available, including truck, rail, barge or air, depending upon customer needs.

Recognized as one of the best facilities of its kind in the country, VTEC has built a solid reputation based upon our precision craftsmanship and dedicated commitment to quality. We take personal pride with our internal processes for handling orders, quality documents and communications with our customers project managers.

Vtec holds stamps and certificates from ASME to build "U", "U2" and "S" pressure vessels and also holds the industry recognized "R" stamp and certificate from the National Board of Boiler Inspectors which allows us to make repairs on existing vessels.

If you need pressure vessel construction you need Vessel Technology.

Our facility provides the structural design and fabrication for vessel sizes up to 200' in length. Shipments weighing up to 400,000 lbs. are possible Our fabrication shop is a 92,000 sq. ft. building located on 44 acres in Longview, Texas, USA. The building consists of (5) 40' wide x 400' long bays with 31' crane hook height and (1) 80' wide x 150' long bay with 40' hook height. (3) 15 ton and (5) 25 ton overhead crane. (4) 35 ton overhead cranes. (2) 100 ton overhead cranes. A Stress Relieving Furnace 17' wide x 19' high x 80' long. VTEC's administration offices are located in a 7,000 sq. ft. office building at the plant site.

Our facility is centrally located - near major transportation arteries allowing full-size shipment of most vessels.

Fitter/welder staff with more than 35 years experience building pressure vessels.

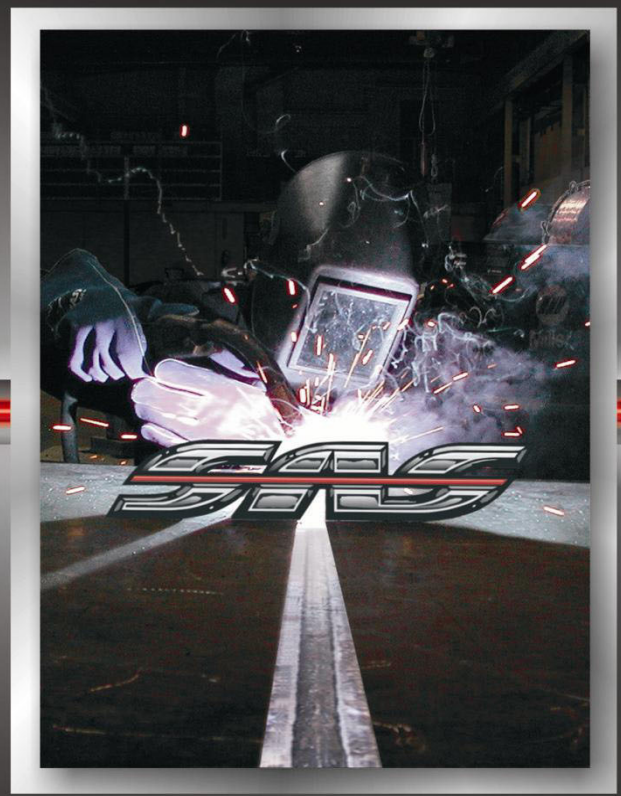
Vessels may be insulated in our shop and shipped to job sites on special cribbing to protect the insulated surfaces.

A 120' x 16' fabrication ships from Vtec's 80' wide x 150' long fabrication bay with over 400,000 lbs. handling capacity.

Vtec can apply most coating systems, internal or external, whether simple primers or multi-part coatings, in our environmentally friendly Blast and Paint Unit.

Vessel internal parts, including trays, special packing, distributors and other process internals can usually be installed at our facility prior to shipment, therefore, saving our customers additional field installation costs.

Industries Served



SURE ALLOY STEEL

25880 Commerce Drive, Madison Heights MI 48071 248-414-4470 Fax 248-414-4480

CLADTEC

FM 2011 South Route 3 Box 58A Longview, TX 75603 800-281-3510 Fax 903-643-7334

ASTECH

P.O. Box 158 5512 Scotch Rd. Vassar, MI 48768 800-327-8474 Fax 517-823-7214

VTEC

FM 2011 South Route 3 Box 58A Longview, TX 75603 903-643-9111 Fax 903-643-9682

What are the Sources of LOI

IMPROPER COAL PARTICLE SIZE

POOR FUEL PIPE BALANCE

UNEVEN DISTRIBUTION of AIR/COAL THROUGH THE BURNER

POORLY TUNED BURNERS

Oversized Coal Particles are a source of LOI

- **NOT ENOUGH SURFACE AREA FOR COMPLETE CHEMICAL REACTION OF COMBUSTION**
- **LACK OF RESONANCE TIME IN THE BOILER FOR LARGER COAL PARTICLES TO COMPLETE COMBUSTION**

Poor Fuel Pipe Balance is a Source of LOI

- **PIPES RICH IN FUEL HAVE HEAVY COAL ROPES AND GENERALLY HAVE LOWER AIRFLOWS**
- **HEAVY COAL ROPING IS A SOURCE FOR INCOMPLETE COMBUSTION**
- **PIPES HAVING HEAVIER COAL FLOW WILL REQUIRE ADDITIONAL SECONDARY AIR AT THE BURNER**
- **BALANCING OF SECONDARY AIRFLOW TO COMPENSATE FOR UNEVEN COAL FLOW IS DIFFICULT TO ACCOMPLISH AND DOES NOT GUARANTEE MIXING OF THE AIR AND COAL**

IMPROPER DISTRIBUTION OF AIR AND COAL THROUGH THE BURNER

- **BURNER ELBOWS EITHER CREATE ROPES OR ALLOW THEM TO PASS THROUGH TO THE BURNER**
- **MOST BURNER ELBOWS ARE NOT ALIGNED WITH THE VERTICLE AXIS OF THE BURNER WHICH CAUSES THE ROPE TO EXIT THE BURNERS AT DIFFERENT ANGLES**
- **COAL ROPES PASS THROUGH THE BURNER INTO THE BOILER**
- **A COAL ROPE IS A SOURCE FOR INCOMPLETE COMBUSTION**

Low NOx Burners operating in any of the aforementioned conditions will be more susceptible to creating LOI

SOLVING THE LOI PROBLEM

- The Source Of The LOI Needs To Be Determined
- Once The Source Has Been Determined Apply The Appropriate Solution

FIND THE SOURCE CREATING THE LOI

- **PERFORM ACCURATE ISOKINETIC COAL PIPE TESTING FOR DIRTY AIR AND COAL PIPE BALANCE**
- **ACCUARCY OF COAL FLOWS FROM TESTING CAN BE VALIDATED BY COMPARING CAPTURED COAL FLOW (CORRECTED FOR MOISTURE LOSS) WITH THE INDICATED CONTROL ROOM COAL FLOW**
- **PERFORM FINENESS TEST ON COLLECTED COAL SAMPLES**

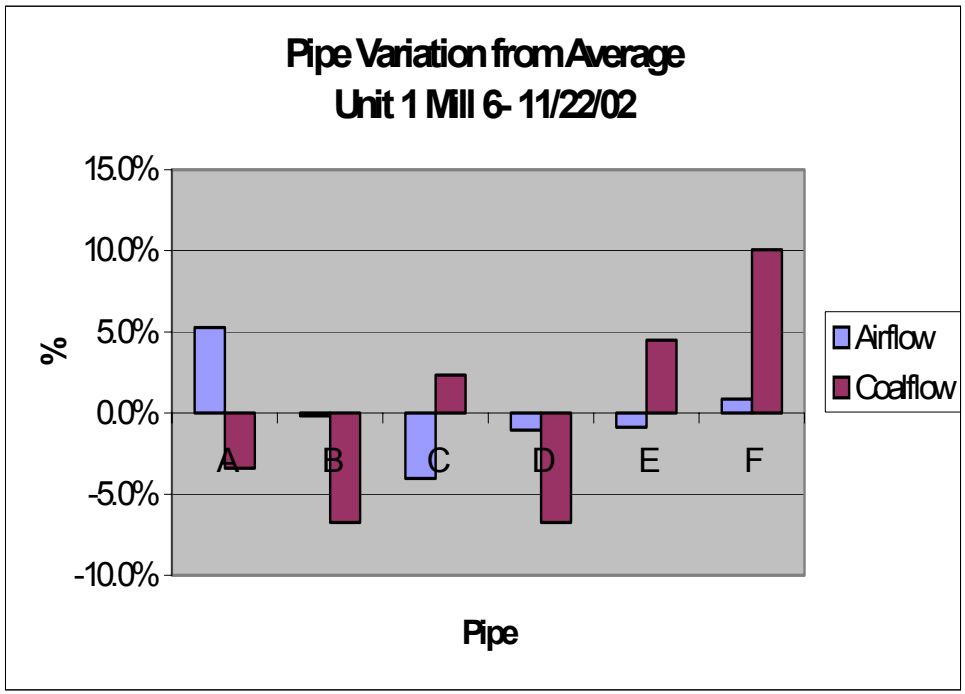
ACFM TEST MACHINE

ACCURATE COAL FLOW MACHINE

- Computer Controlled to Minimize Operator Error
- Air Velocity At Each Test Point Is Recorded In The Computer
- Coal Extraction at each Point is Taken Isokinetically Based Upon Recorded Air Velocity Stored In The Computer
- Two 90 Degree Traverse Samples Are Taken From The Coal Pipe
- Collected Coal From Two Separate Tests Are Compared For Repeatability and Accuracy

MPS 89 COAL PIPE TEST

Pipe	Airflow	Air Balance	Coalflow	Coal Balance	Air/Coal Ratio
A	43199	5.3%	14523	-3.4%	2.97
B	40974	-0.2%	14020	-6.7%	2.92
C	39380	-4.0%	15384	2.3%	2.56
D	40610	-1.0%	14020	-6.7%	2.90
E	40679	-0.9%	15710	4.5%	2.59
F	41394	0.9%	16545	10.1%	2.50
Average	**41039**		**15034**		
Total	**246237**		**90204**		**2.73**
Max Dev		**9.3%**		**16.8%**	



Operating Data for Unit-1 Mill-6

Coal Flow x 1000	102.2
Capacity Sta. Output	50.50
Feeder Spd.	78.20
Outlet Temp.	170.00
Hot Air Temp	350.60
Pulv. Inches H2O	1.93
Pulverizer Diff.	14.00
Pulverizer Motor Amps	86.00

Unit-1 Mill-6	Estimated Flows	
Air-dry	234636	lbs/hr
Coal-wet	96104	lbs/hr
A/F Ratio	**2.44**	

FINDING THE SOURCE OF THE LOI

- ANALYZE THE SOURCE OF CARBON IN THE FLY ASH
- FIRST DETERMINE THE ***COMPOSITE LOI PERCENTAGE*** BY TOTALLY BURNING OUT ALL THE CARBON IN A WEIGHED ASH SAMPLE
- NEXT BURN ALL THE CARBON OUT OF AN ASH SAMPLE WHICH HAS BEEN SCREENED THROUGH A 200 MESH SCREEN. THIS WILL DETERMINE THE ***FINE PARTICLE LOI PERCENTAGE***
- THE RELATIONSHIP OF THESE PERCENTAGES WILL DETERMINE IF THE LOI IS FROM POOR COMBUSTION OR POOR COAL FINENESS

CORRECTIVE ACTIONS WHICH NEED TO BE IMPLEMENTED

POOR COAL FINENESS

- INSPECT PULVERIZER FOR MECHANICAL PROBLEMS
- PREFORM REQUIRED MILL MAINTENANCE
- ADJUST CLASSIFIER FOR IMPROVED FINENESS
- ADJUST AND SET PROPER GRINDING CLEARANCES
- ROLL PRESSURES MAY HAVE TO BE INCREASED FOR HARDER TO GRIND COALS

COAL ROPING AT THE BURNER

- **IT IS VERY IMPORTANT TO ELIMINATE COAL ROPES BEFORE THEY ENTER THE BOILER**
- **IMPLEMENT DIFFUSION MODIFICATIONS TO BREAK UP COAL ROPES BEFORE THEY LEAVE THE BURNER TIP**

COAL PIPE IMBALANCE

- **THE MOST COMMON METHOD USED BY THE POWER INDUSTRY IN AN ATTEMPT TO BALANCE COAL PIPES IS AN ORIFICE**
- **ORIFICES ARE USED TO RESTRICT THE FLOW OF BOTH AIR AND COAL IN INDIVIDUAL PIPES**

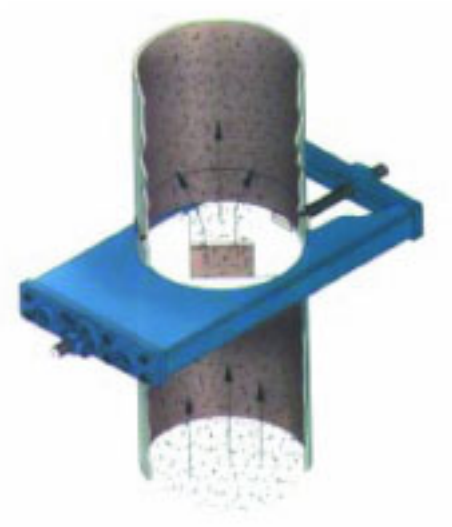
TYPES OF ORIFICES

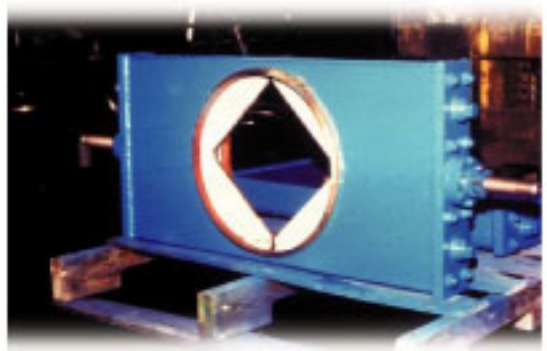
- **PLATE STYLE ORIFICE**
- **VENTURI STYLE ORIFICE**
- **ADJUSTABLE STYLE ORIFICE**

PLATE STYLE ORIFICES

VENTURI STYLE ORIFICE

ADJUSTABLE STYLE ORIFICE





DO ORIFICES WORK ?

- **IT IS RARE TO SEE AIRFLOW AND COAL FLOW BALANCED BY JUST USING ORIFICES**
- **POWER PLANTS HAVE USED ORIFICES OF ALL TYPES FOR MANY YEARS, YET MOST STILL SUFFER FROM POOR COAL PIPE BALANCE**

Problems with fixed sized Orifices

- CHANGING AN ORIFICE REQUIRES THE PULVERIZER TO BE REMOVED FROM SERVICE
- ANY CHANGE MADE TO AN ORIFICE WILL HAVE AN EFFECT ON THE COAL AND AIR BALANCE OF THE OTHER PIPES
- VERIFICATON OF COAL PIPE BALANCE CHANGES HAVE TO BE DETERMINED BY COAL PIPE TESTING

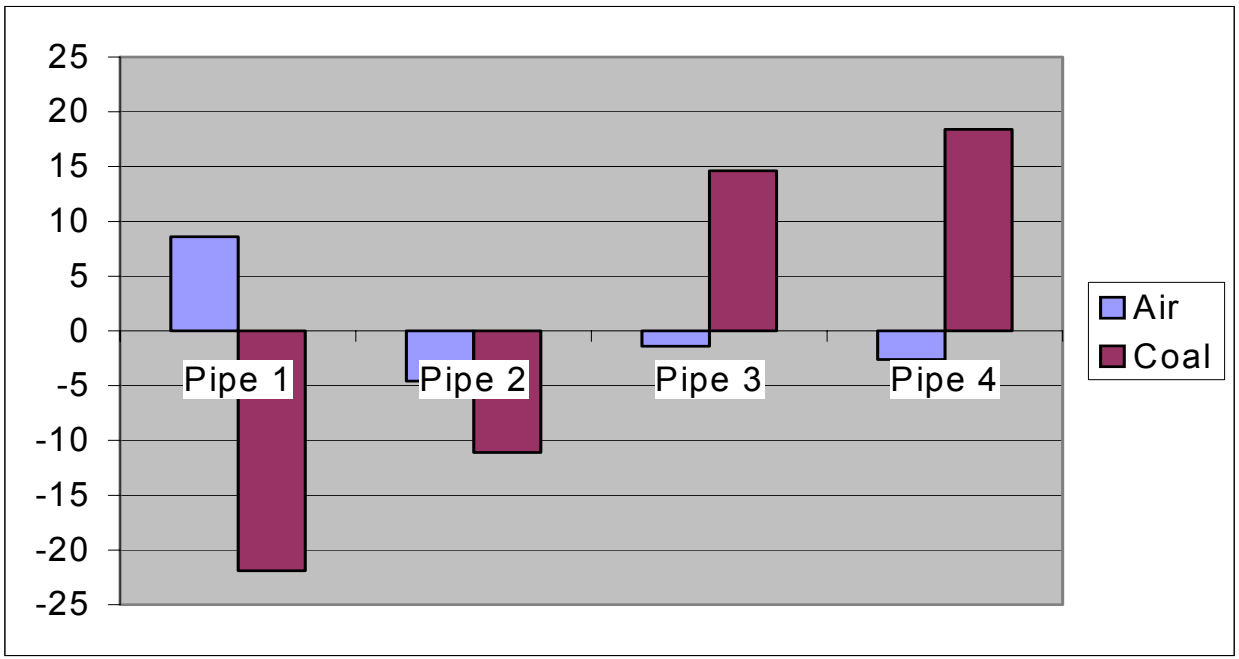
USING ADJUSTABLE ORIFICES

- ABLE TO MAKE CHANGES WHILE THE PULVERIZER IS OPERATING
- ADJUSTMENTS IN ONE PIPE WILL STILL AFFECT THE OTHER PIPES
- BALANCING BECOMES A MOVING TARGET
- TYPICAL IMPROVEMENT IN COAL BALANCE IS AT THE EXPENSE OF AIR BALANCE

Typical Coal Balance Problem

ORIFICE PIPE 4 TO BALANCE COAL

	Pipe 1	Pipe 2	Pipe 3	Pipe 4
Air	8.6	-4.6	-1.4	-2.6
Coal	-21.9	-11.1	14.6	18.4



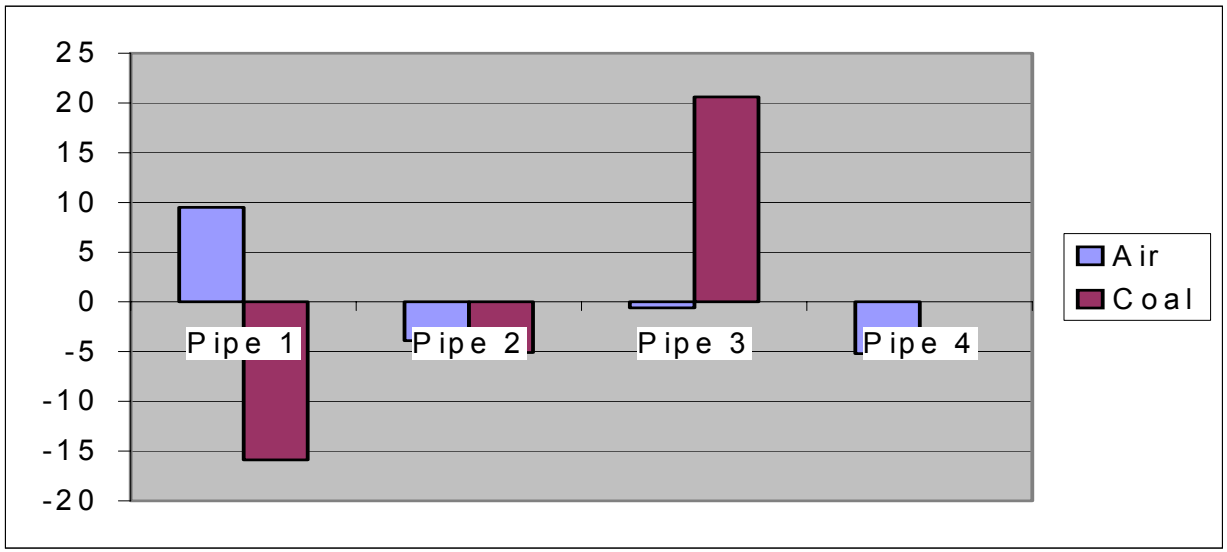
Maximum Air Deviation	**13.20%**
Maximum Coal Deviation	**40.30%**

WHAT MIGHT HAPPEN IF PIPE 4 HAS A SMALLER ORIFICE INSTALLED

Orifice Pipe 4 to Zero Coal Deviation

Flow from Pipe 4 divided equally between other three pipes

	Pipe 1	Pipe 2	Pipe 3	Pipe 4
Air	9.5	-3.9	-0.6	-5.2
Coal	-15.9	-5.1	20.6	0

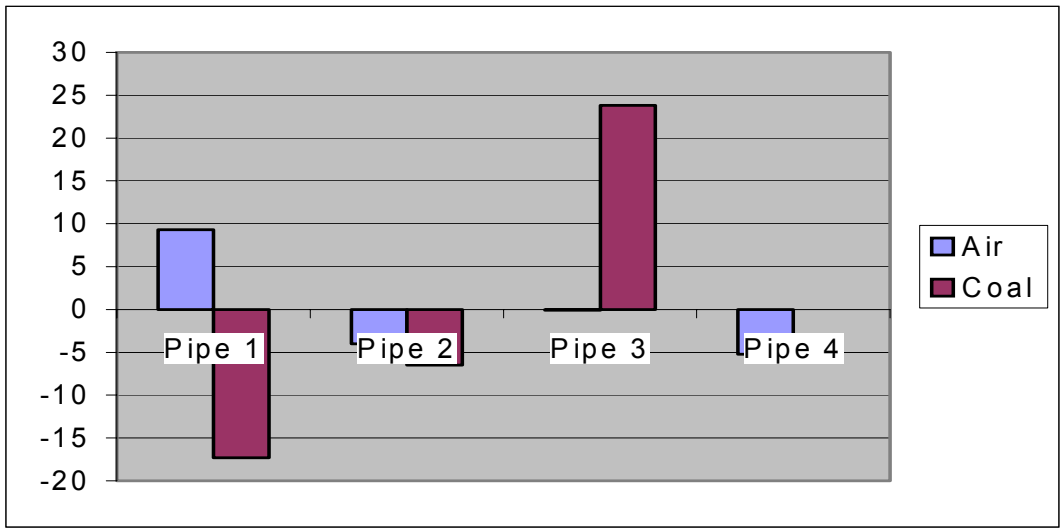


Maximum Air Deviation	14.70%
Maximum Coal Deviation	36.50%

MAYBE THIS MIGHT HAPPEN
ONLY TESTING WILL PROVIDE THE ANSWER

Orifice Pipe 4 to Zero Coal Deviation
1/2 of Coal and Air sent to Pipe 3
1/4 of Coal and Air sent to Pipe 1 and Pipe 2
Pipe Three Might Receive More Coal Since It was Already High

	Pipe 1	Pipe 2	Pipe 3	Pipe 4
Air	9.3	-4	-0.1	-5.2
Coal	-17.3	-6.5	23.8	0



Maximum Air Deviation	14.50%
Maximum Coal Deviation	41.10%

Common Mistakes With Orifices

- **Don’t waste time and money orificing for clean airflow. The final correct orifice size for dirty airflow is different than the size used to balance clean airflow**
- **Orifices may restrict the airflow to the point coal may lose velocity and settle out in the piping system**
- **Orifices may increase the system resistance of primary airflow into the pulverizer causing the mill to pyrite coal**

WHAT IF THERE WAS ANOTHER WAY TO BALANCE COAL PIPES ?

THE SOURCE OF THE BALANCE PROBLEM

- IMBALANCE IS GENERATED WITHIN THE PULVERIZER
- COAL FLOWING INTO THE CLASSIFIER STARTS TO CREATE COAL ROPES
- THESE COAL ROPES CONTINUE INTO THE DISCHARGE OF THE UPPER TURRET OF THE PULVERIZER
- THE ROPES NOW ENTER THE FUEL PIPING SYSTEM

DIFFUSION TECHNOLOGY
THE SOLUTION

- **ADDRESSES THE PROBLEM , NOT THE SYMPTOMS**
- **PROMOTES HOMOGENOUS MIXTURE OF COAL AND AIR**
- **PATENTS AND PATENTS PENDING, SAS TECHNOLOGY**

MULTI-OUTLET DIFFUSER

- DESIGNED FOR PRESSURIZED COAL MILLS WITH MULTIPLE COAL PIPES FUELING THE BOILER
- WORKS WITHIN THE UPPER TURRET SECTION OF THE PULVERIZER
- DESTROYS COAL ROPES BEFORE THEY CAN ENTER THE COAL PIPING SYSTEM
- PREVENTS COAL ROPES FROM REFORMING PRIOR TO LEAVING THE PULVERIZER
- WORKS WITHIN A WIDE RANGE OF PRESSURIZED PULVERIZERS

MULTI-OUTLET DIFFUSER IN SERVICE

CASE STUDY

- FRONT AND REAR FIRED WALL BOILER
- (3) MPS 75 PULVERIZERS EACH HAVING 6 COAL PIPES
- DYNAMIC CLASSIFERS ON EACH PULVERIZER
- 16% LOI AFTER LOW NOx BURNER RETROFIT
- ACCEPTABLE COAL FINENESS WITH 1% RETAINED ON 50 MESH AND 68% PASSING THROUGH 200 MESH
- BURNING PRIMARILY EASTERN COAL AND SYN-FUEL
- O2 AND CO MAPPING IN THE BOILER DEMONSTRATED SEVERE FUEL PIPE IMBALANCE PROBLEMS

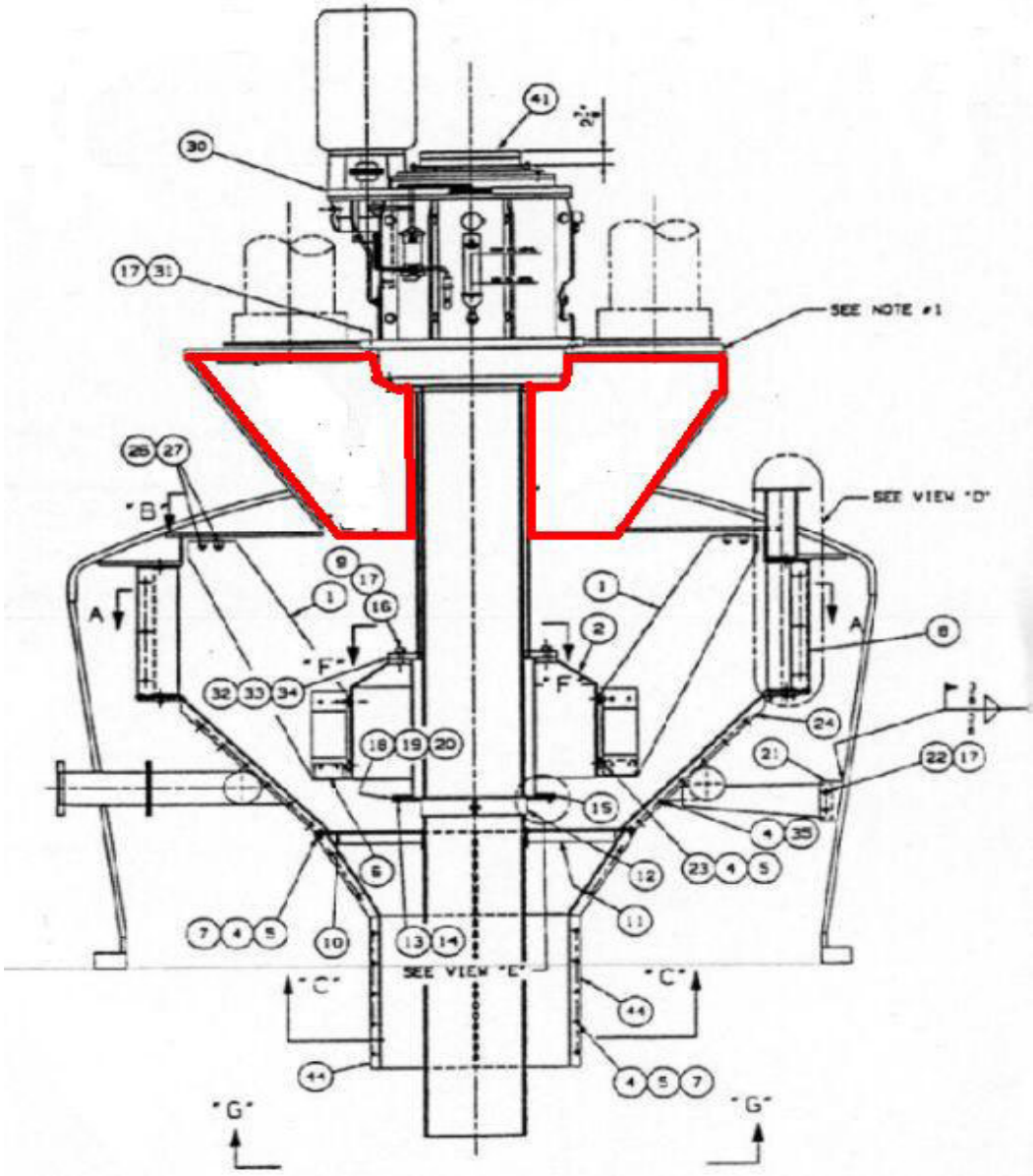
CASE STUDY

- **THE POWER PLANT REPLACED ALL VENTURI FIXED ORIFICES WITH ADJUSTABLE ORIFICES.**
- **THE POWER PLANT ATTEMPTED TO ADJUST SECONDARY AIR FLOWS TO COMPENSATE FOR COAL PIPE IMBALANCE**
- **NUMEROUS ATTEMPTS TO BALANCE COAL PIPES WITH THE ADJUSTABLE ORIFICES FAILED.**

CASE STUDY

- **THE PLANT INSTALLED MULTI-OUTLET DIFFUSERS IN ALL THREE PULVERIZERS**
- **THE PLANT REINSTALLED THE VENTURI ORIFICES**
- **COAL PIPE BALANCE IMPROVED BY 78%**
- **THERE WAS A 56% REDUCTION IN LOI**
- **LOI WAS LOWERED from 16% TO UNDER 7%**
- **NOx WAS LOWERED AT THE SAME TIME**

MPS 75 UPPER TURRET



MULTI-OUTLET DIFFUSER
Pre and Post Coal Pipe Balance
FOR “C” Pulverizer

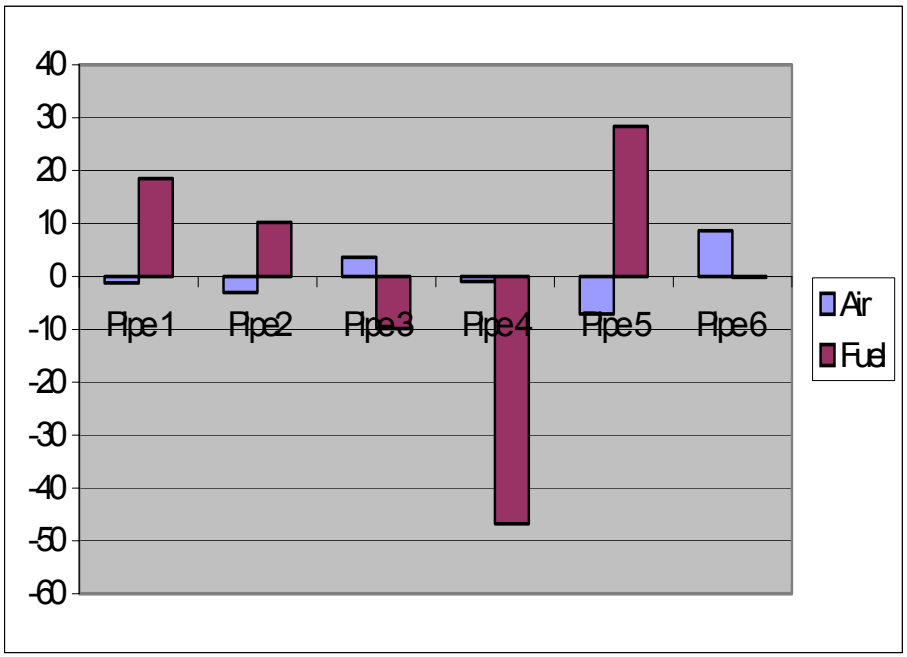
MPS 75 PULVERIZER

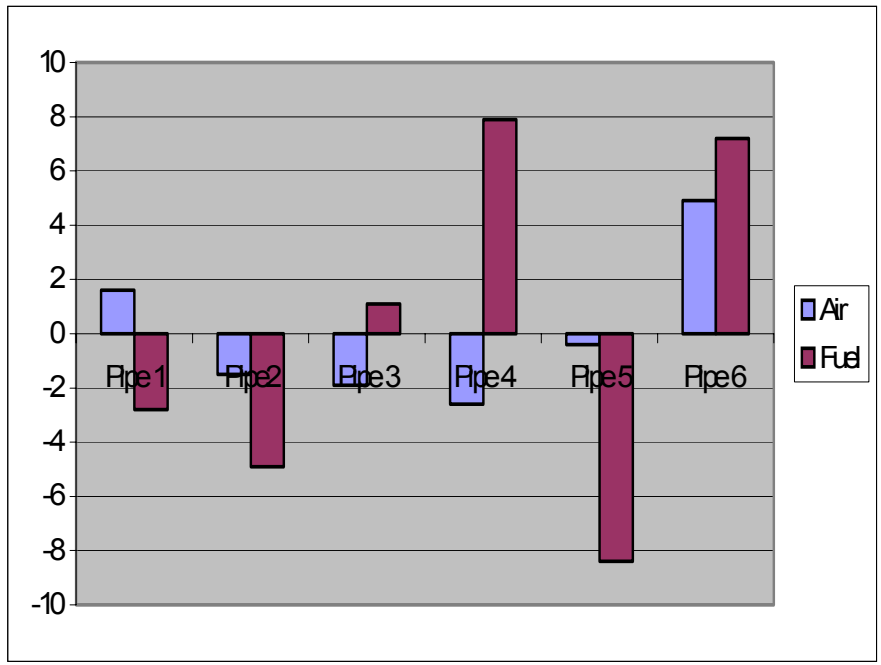
Pre Test Results

	Pipe 1	Pipe 2	Pipe 3	Pipe 4	Pipe 5	Pipe 6
Air	-1.2	-3	3.6	-1	-7.1	8.6
Fuel	18.5	10.2	-9.9	-46.8	28.3	-0.2

Post Test Results

	Pipe 1	Pipe 2	Pipe 3	Pipe 4	Pipe 5	Pipe 6
Air	1.6	-1.5	-1.9	-2.6	-0.4	4.9
Fuel	-2.8	-4.9	1.1	7.9	-8.4	7.2





Max AIR Deviation 15.70%
Max Coal Deviation 75.10%

Max Air Deviation 7.50%
Max Coal Deviation 16.30%

78% improvement in coal balance

Other Advantages of the Multi-Outlet Diffuser

- **The usage of orifices to match individual pipe resistance is much more effective with the coal evenly distributed exiting the pulverizer**
- **There is a substantial improvement in the air to fuel ratio balance across all of the pulverizers fuel pipes**
- **A balanced fuel delivery system allows for more subtle adjustments in secondary and tertiary air for precise tuning of the boiler.**

OTHER DIFFUSERS

- Pre-Riffle Mixer improves the distribution of air and coal passing through a riffle. Premixing the air and coal prior to the riffle not only improves balance it may eliminate the need of a riffle element
- The In-Line Diffuser is used upstream of the burner nozzle. Stratified coal and primary air are mixed just as they enter the nozzle tip and exit into the boiler creating and ideal mixture for combustion. This diffused mixture helps many problems associated with burner performance including: flame instability/detachment, eyebrows, increased LOI, fuel impingement on boiler walls, imbalance in Co and O2, excessive slagging, and problems adjusting low NOx burners

Other examples of Multi-Outlet Diffuser Pre and Post Test Coal Pipe Balance

B&W EL Pulverizer

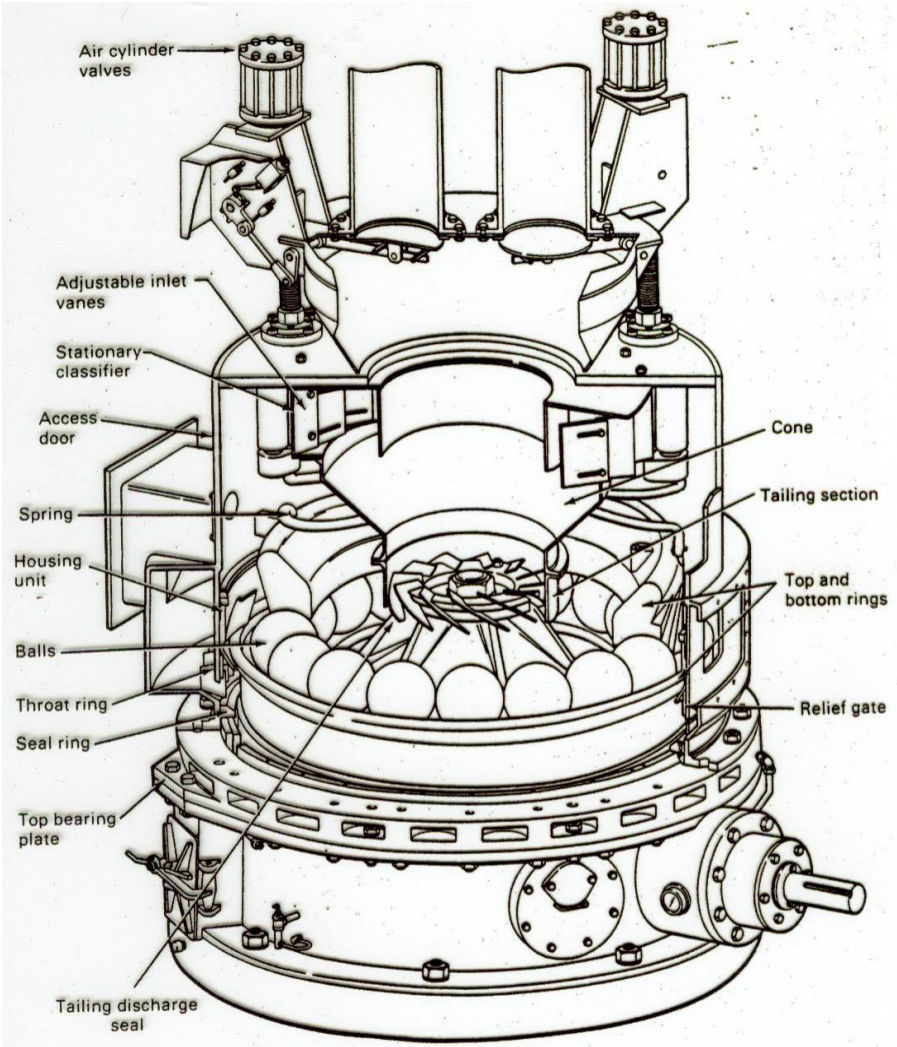
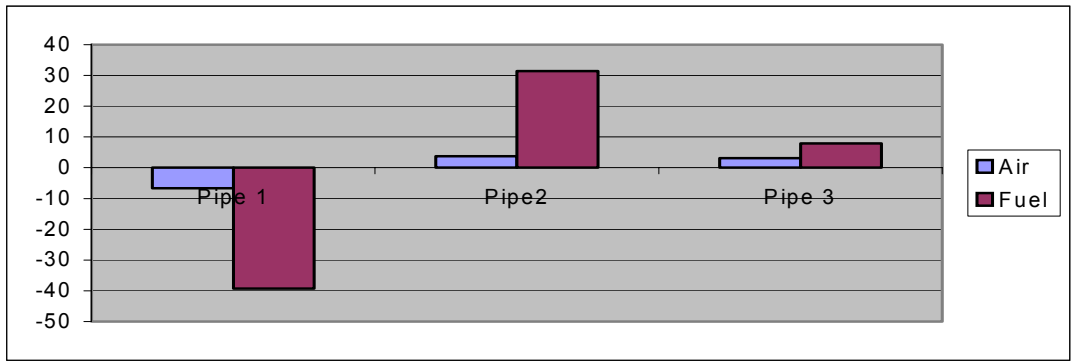


Fig. 1 EL Pulverizer.

B&W EL 56 PULVERIZER

Pre Test Results

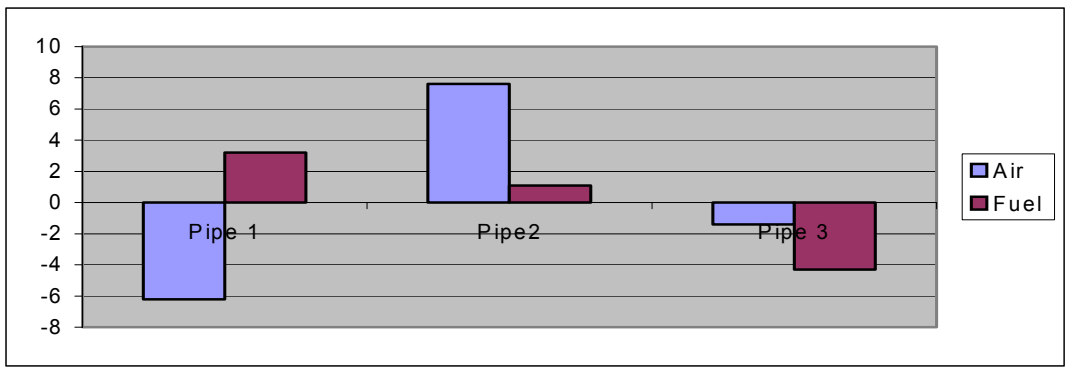
	Pipe 1	Pipe2	Pipe 3
Air	-6.7	3.7	3.1
Fuel	-39.3	31.4	7.9



Maximum Air Deviation **10.40%**
Maximum Coal Deviation **70.60%**

Post Test Results

	Pipe 1	Pipe2	Pipe 3
Air	-6.2	7.6	-1.4
Fuel	3.2	1.1	-4.3



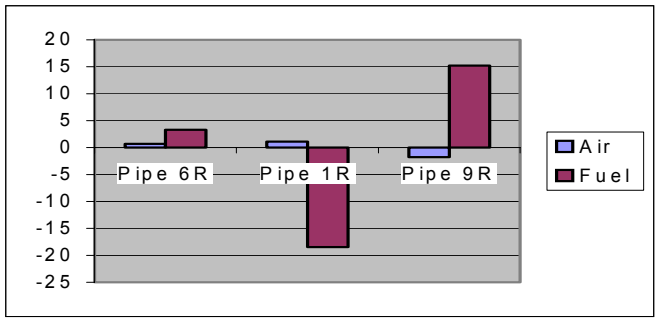
Maximum Air Deviation **13.80%**
Maximum Coal Deviation **7.40%**

Approximately 90% improvement in Coal Balance

RILEY BALL MILL PULVERIZER

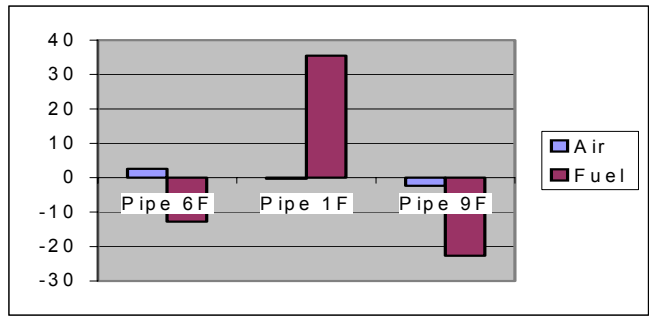
Pre Test Results

	Pipe 6R	Pipe 1R	Pipe 9R
Air	0.7	1.1	-1.8
Fuel	3.3	-18.5	15.2



Maximum Air Deviation	2.90%
Maximum Coal Deviation	33.70%

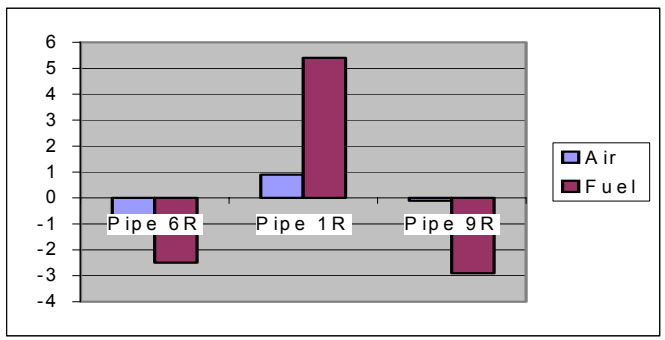
	Pipe 6F	Pipe 1F	Pipe 9F
Air	2.6	-0.3	-2.3
Fuel	-12.8	35.5	-22.7



Maximum Air Deviation	4.90%
Maximum Coal Deviation	58.20%

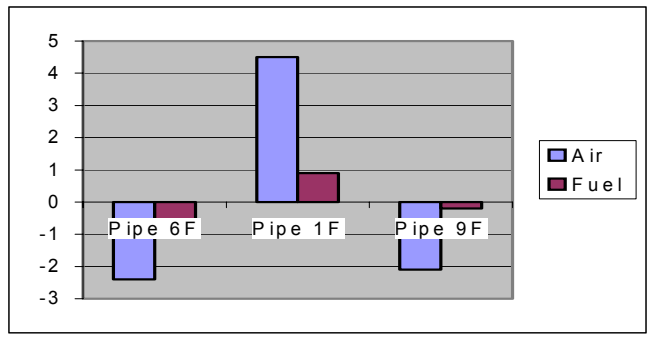
Post Test Results

	Pipe 6R	Pipe 1R	Pipe 9R
Air	-0.8	0.9	-0.1
Fuel	-2.5	5.4	-2.9



Maximum Air Deviation	1.70%
Maximum Coal Deviation	8.30%

	Pipe 6F	Pipe 1F	Pipe 9F
Air	-2.4	4.5	-2.1
Fuel	-0.7	0.9	-0.2

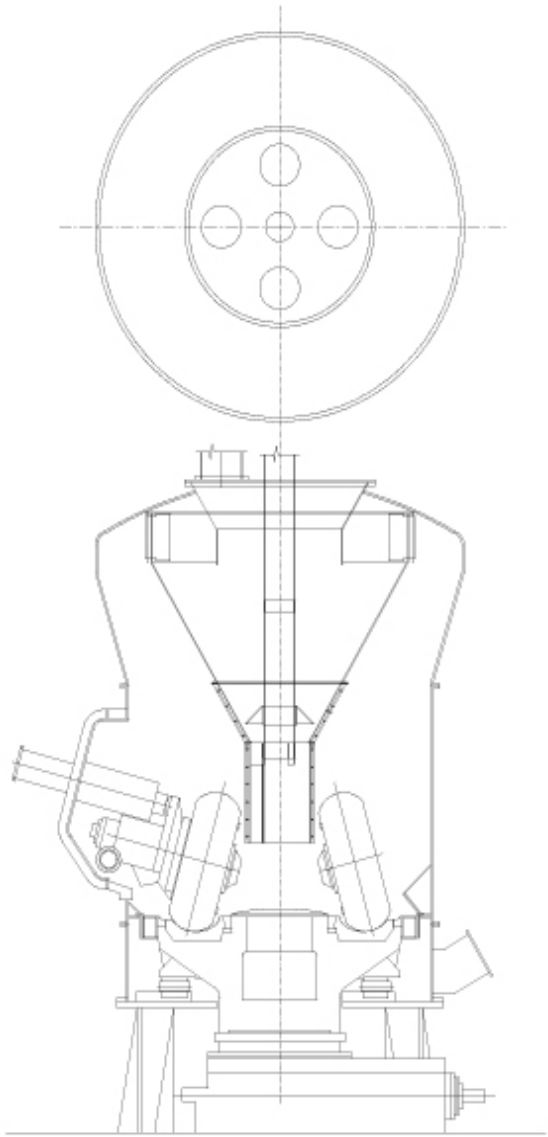


Maximum Air Deviation	6.9%
Maximum Coal Deviation	1.60%

Approximately 75% improvement in Coal Balance from one Classifier

Approximately 97% improvement in Coal Balance from the other Classifier

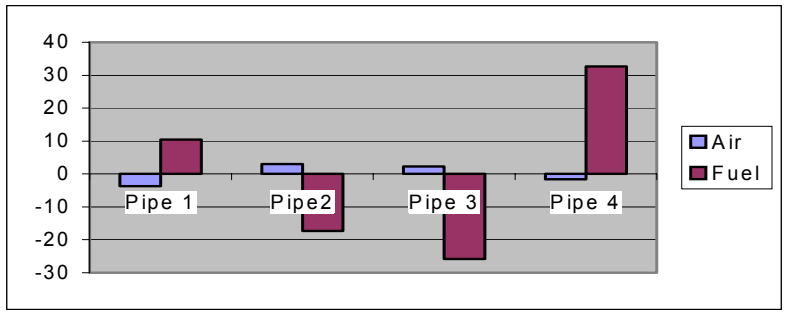
FOSTER WHEELER MBF



FOSTER WHEELER MBF23

Pre Test Results

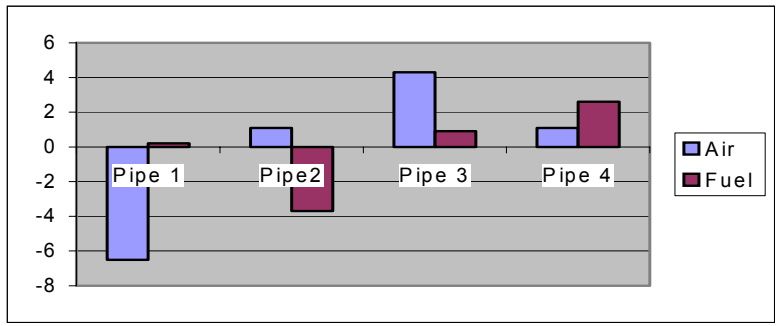
	Pipe 1	Pipe2	Pipe 3	Pipe 4
Air	-3.7	3	2.3	-1.6
Fuel	10.4	-17.3	-25.8	32.7



Maximum Air Deviation **6.70%**
Maximum Coal Deviation **58.50%**

Post Test Results

	Pipe 1	Pipe2	Pipe 3	Pipe 4
Air	-6.5	1.1	4.3	1.1
Fuel	0.2	-3.7	0.9	2.6



Maximum Air Deviation **10.80%**
Maximum Coal Deviation **6.30%**

Approximately 90% Improvement in Coal Balance

CE HP Pulverizer

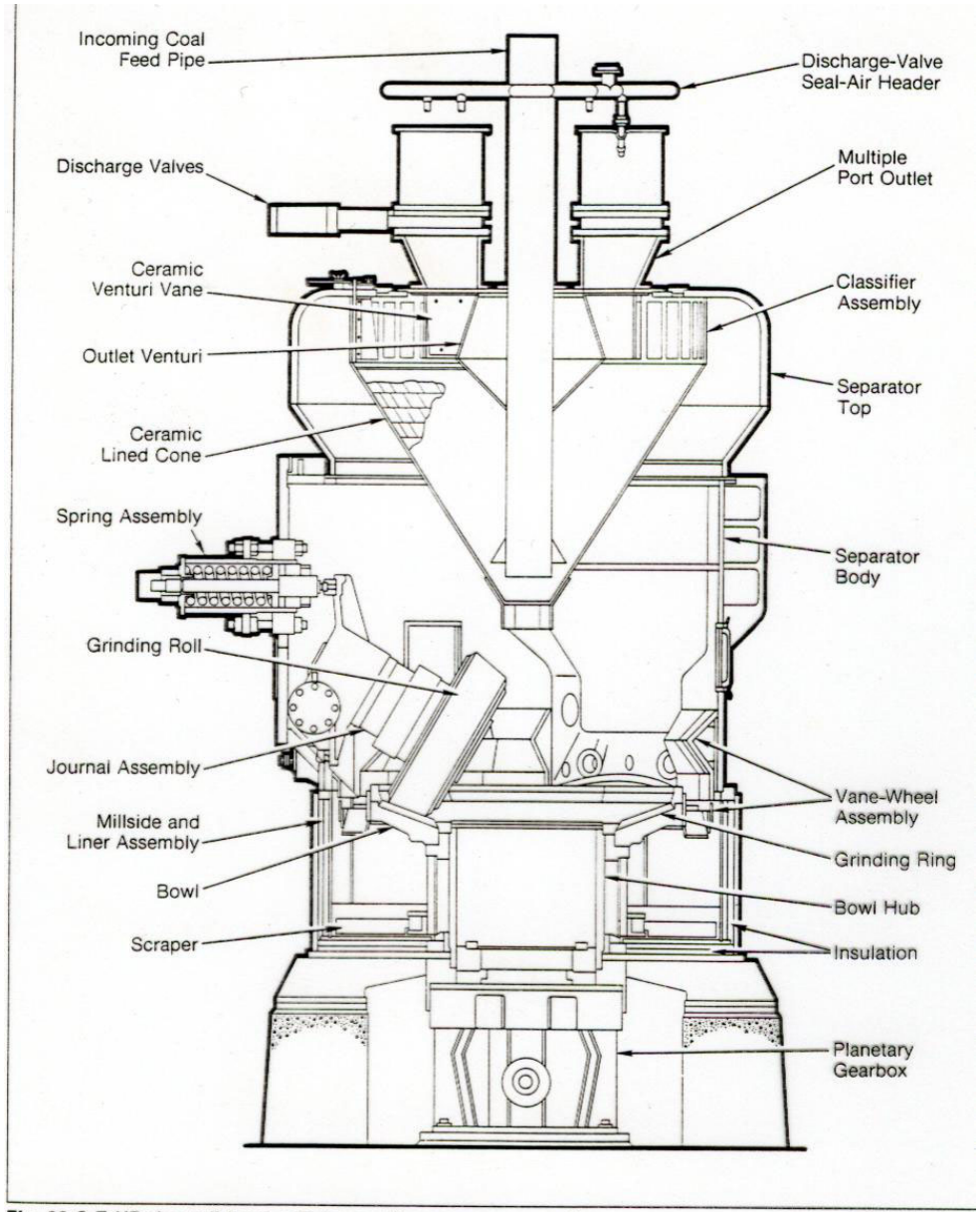
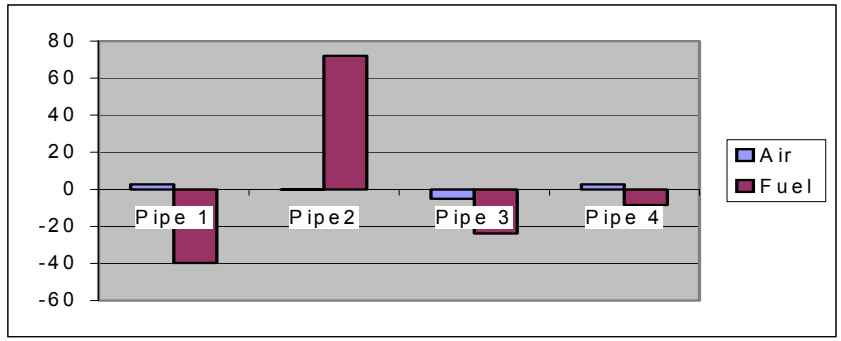


Fig. 26 C-E HP ring-roll bowl mill for positive-pressure operation

CE 863 HP PULVERIZER

Pre Test Results

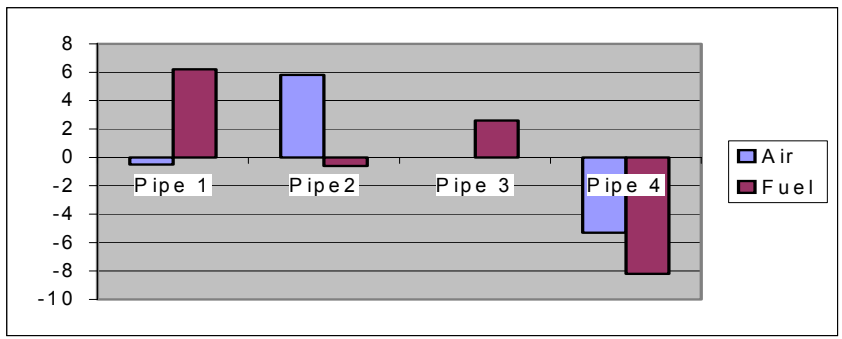
	Pipe 1	Pipe2	Pipe 3	Pipe 4
Air	2.7	-0.2	-5.2	2.7
Fuel	-39.7	72	-23.8	-8.5



Maximum Air Deviation **7.90%**
Maximum Coal Deviation **111.70%**

Post Test Results

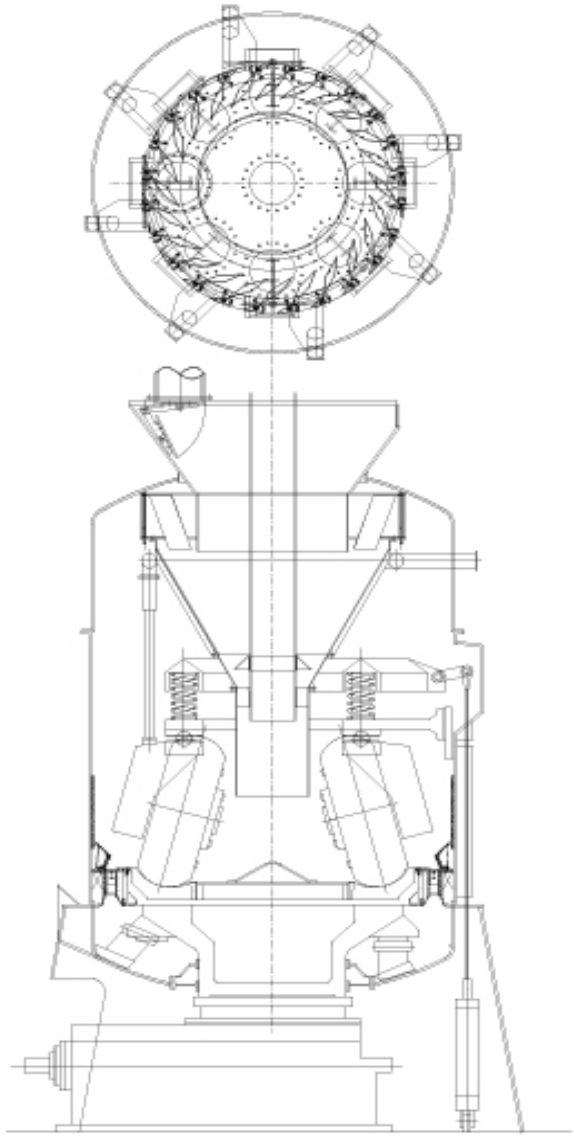
	Pipe 1	Pipe2	Pipe 3	Pipe 4
Air	-0.5	5.8	0	-5.3
Fuel	6.2	-0.6	2.6	-8.2



Maximum Air Deviation **11.20%**
Maximum Coal Deviation **14.40%**

87% improvement in coal balance

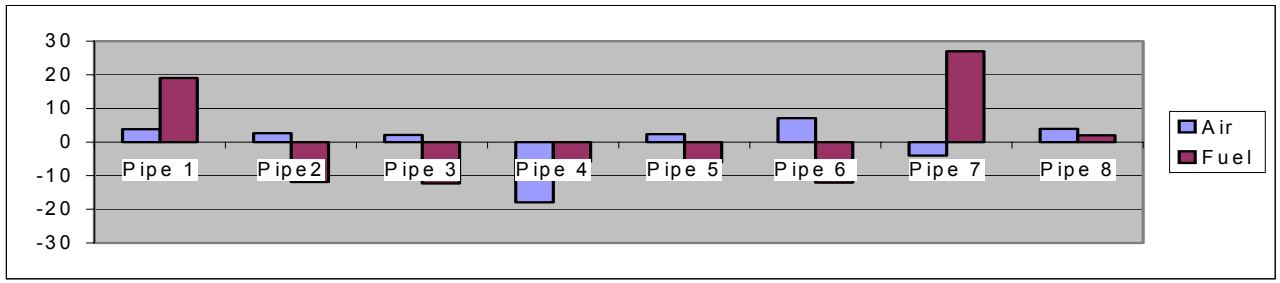
MPS 89 PULVERIZER



MPS 89 with 8 Pipes

Pre Test Results

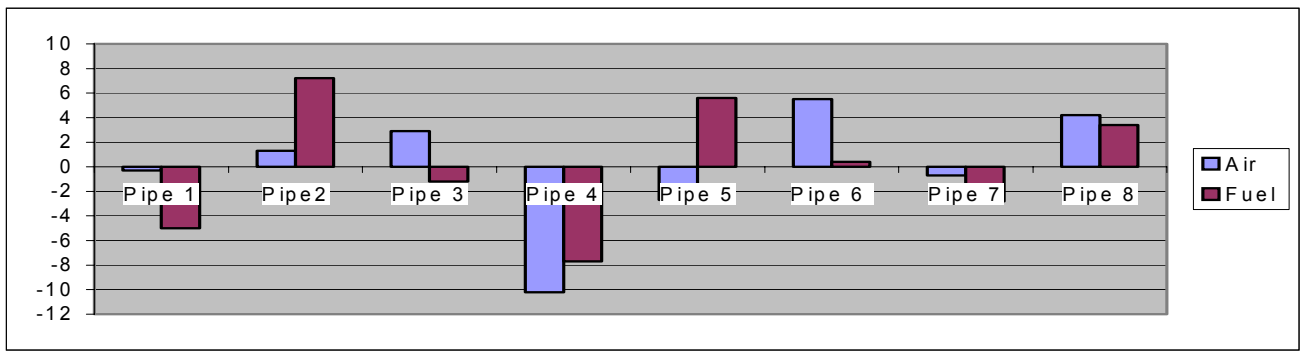
	Pipe 1	Pipe2	Pipe 3	Pipe 4	Pipe 5	Pipe 6	Pipe 7	Pipe 8
Air	3.8	2.6	2.1	-17.9	2.4	7.1	-4	3.9
Fuel	19	-11.9	-12.3	-5.8	-6	-12	27	2



Maximum Air Deviation **25%** **Opposites** **5 out of 8**
Maximum Coal Deviation **39.30%**

Post Test Results

	Pipe 1	Pipe2	Pipe 3	Pipe 4	Pipe 5	Pipe 6	Pipe 7	Pipe 8
Air	-0.3	1.3	2.9	-10.2	-2.7	5.5	-0.7	4.2
Fuel	-5	7.2	-1.2	-7.7	5.6	0.4	-2.8	3.4



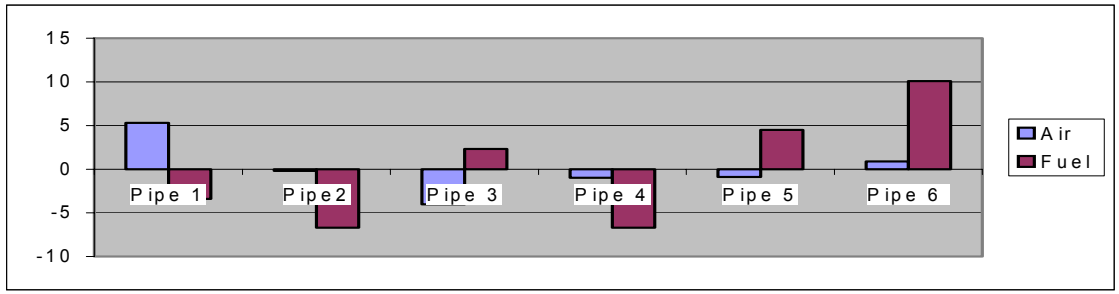
Maximum Air Deviation **15.70%** **Opposites** **2 out of 8**
Maximum Coal Deviation **14.90%**

62% improvement in coal pipe balance

MPS 89 with 6 Pipes

Pre Test Results

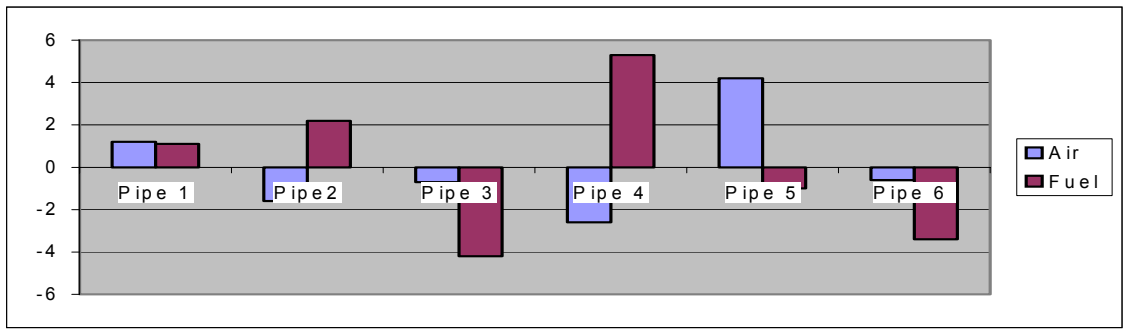
	Pipe 1	Pipe2	Pipe 3	Pipe 4	Pipe 5	Pipe 6
Air	5.3	-0.2	-4	-1	-0.9	0.9
Fuel	-3.4	-6.7	2.3	-6.7	4.5	10.1



Maximum Air Deviation **9.30%**
Maximum Coal Deviation **16.80%**

Post Test Results

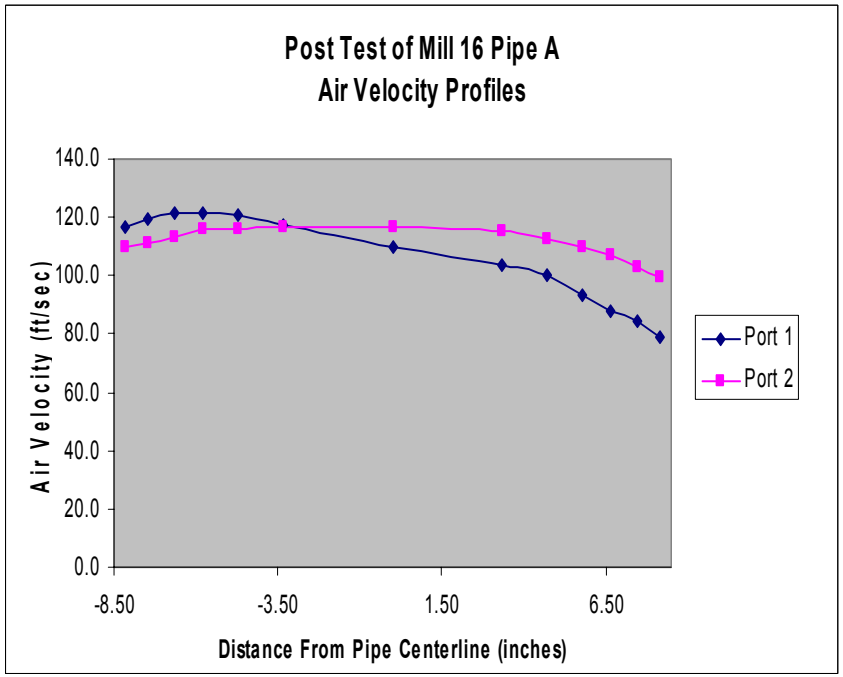
	Pipe 1	Pipe2	Pipe 3	Pipe 4	Pipe 5	Pipe 6
Air	1.2	-1.6	-0.7	-2.6	4.2	-0.6
Fuel	1.1	2.2	-4.2	5.3	-1	-3.4

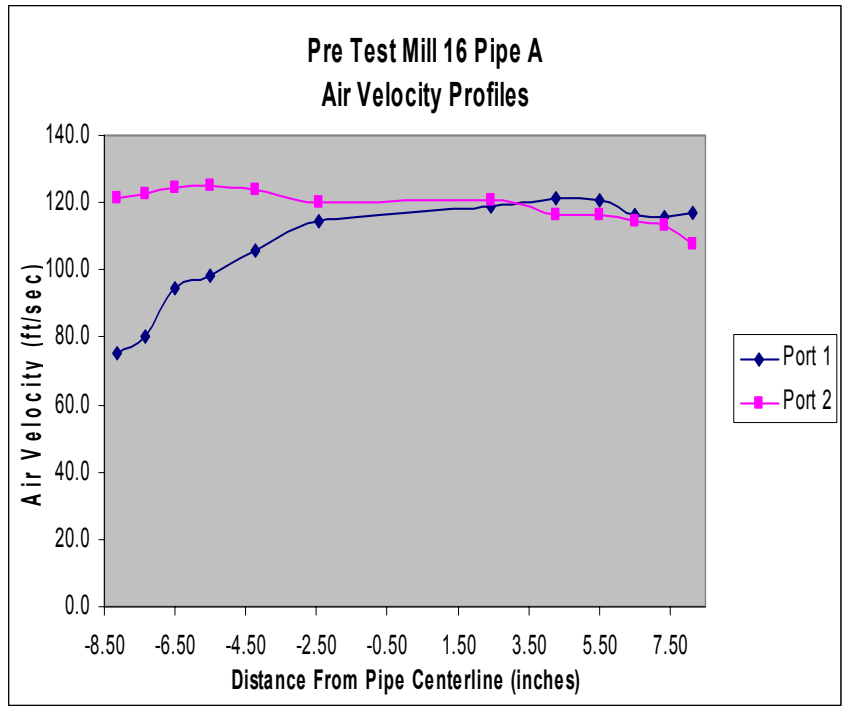


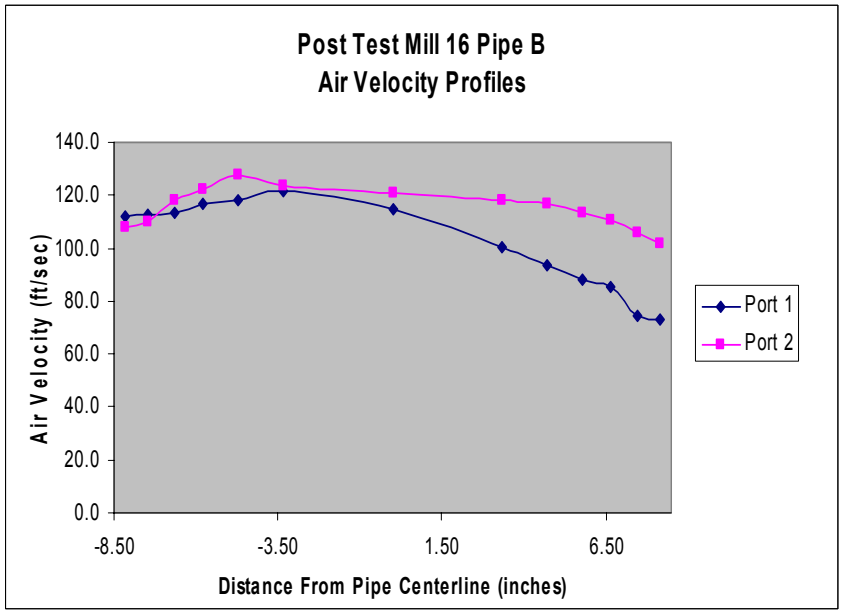
Maximum Air Deviation **6.80%**
Maximum Coal Deviation **9.50%**

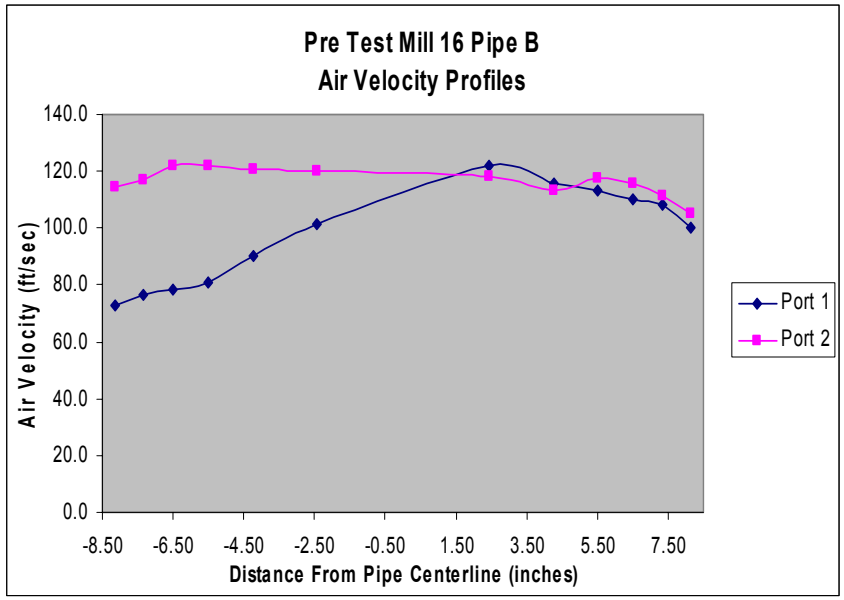
44% improvement in Coal Balance

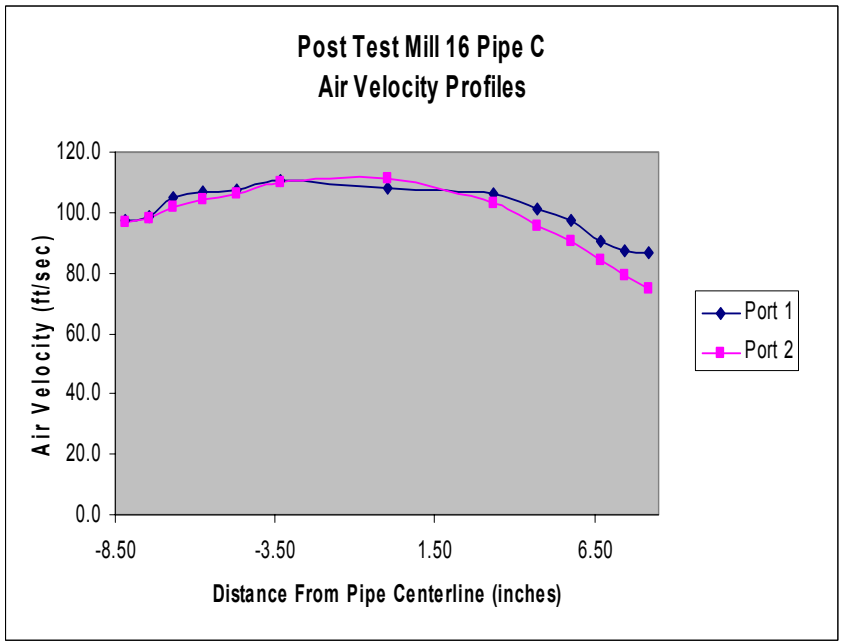
Pre and Post Air Velocity
MPS 89 with 6 Pipes

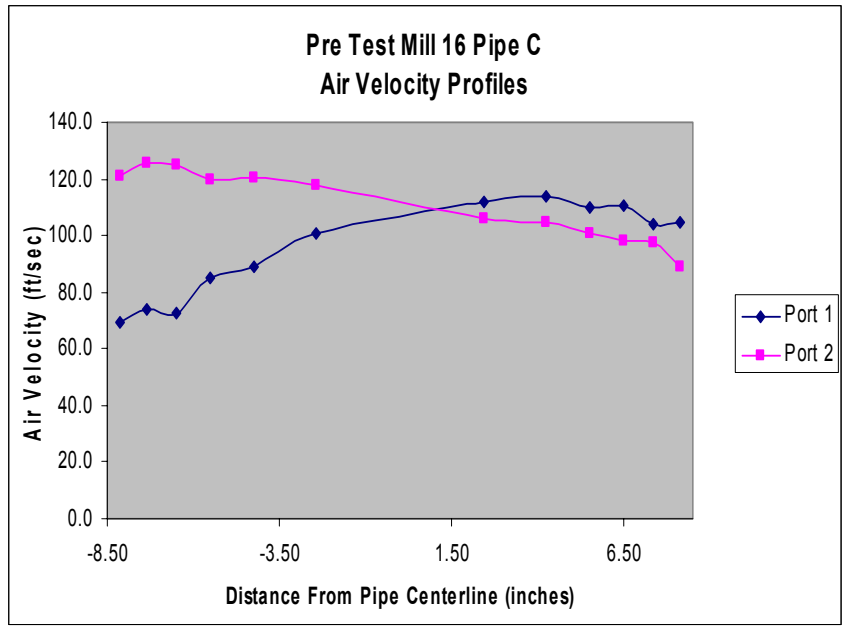

Post Test of Mill 16 Pipe A
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

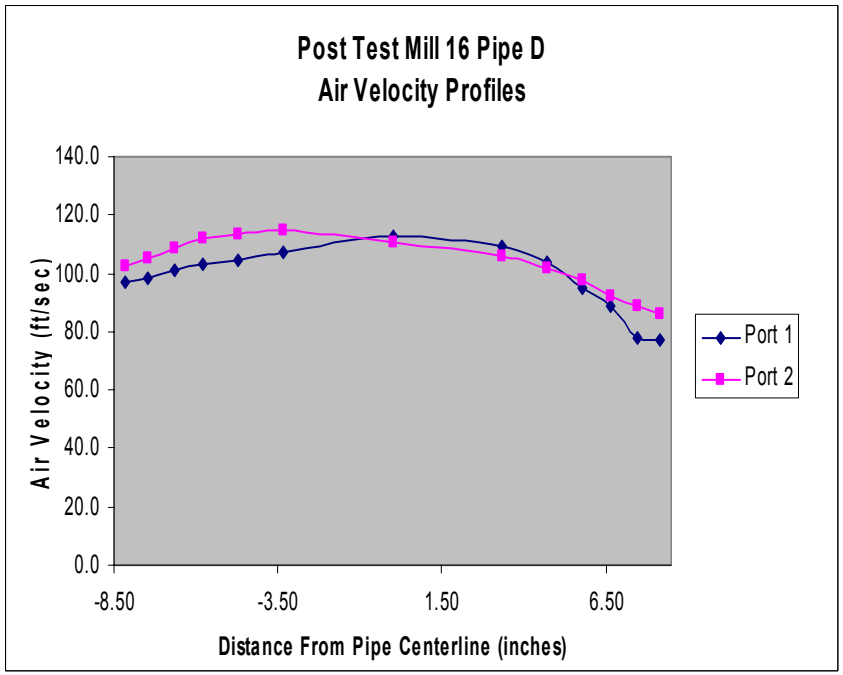

Pre Test Mill 16 Pipe A
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-6.50
-4.50
-2.50
-0.50
1.50
3.50
5.50
7.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

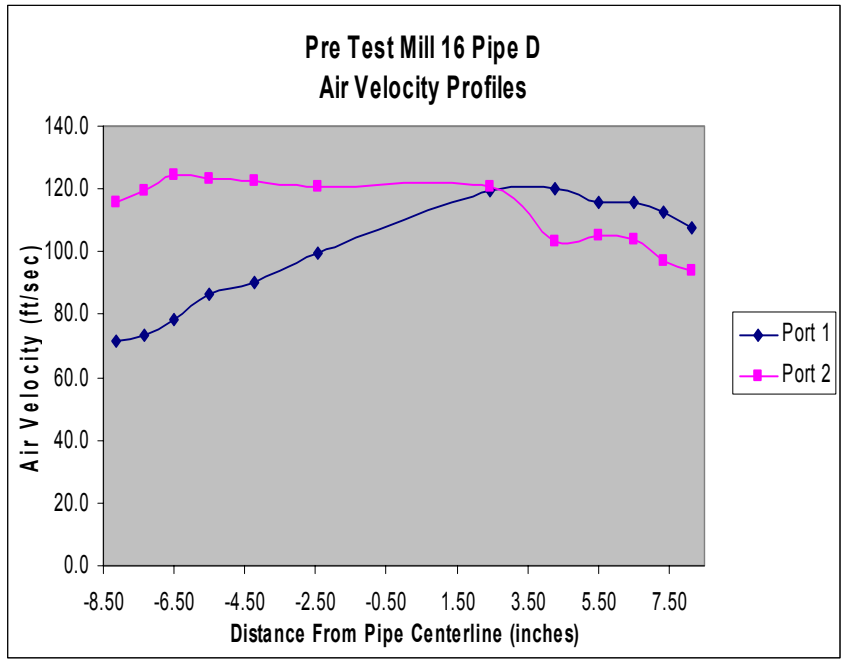

Post Test Mill 16 Pipe B
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

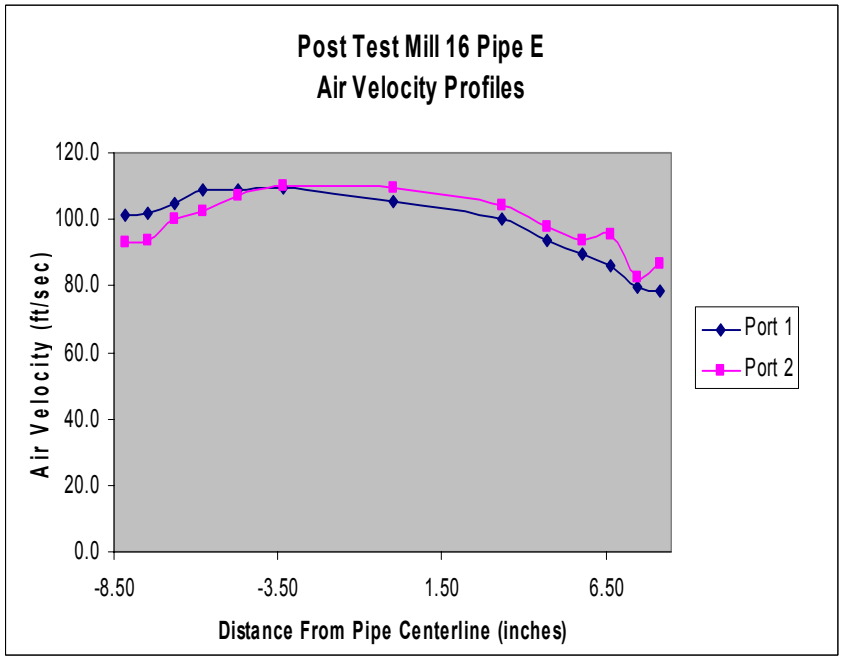

Pre Test Mill 16 Pipe B
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-6.50
-4.50
-2.50
-0.50
1.50
3.50
5.50
7.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

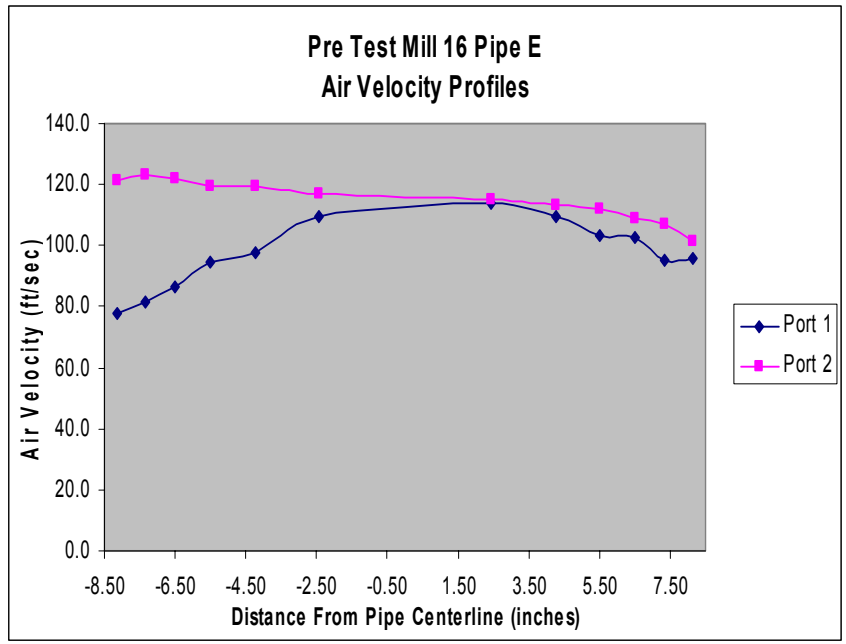

Post Test Mill 16 Pipe C
Air Velocity Profiles
Air Velocity (ft/sec)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

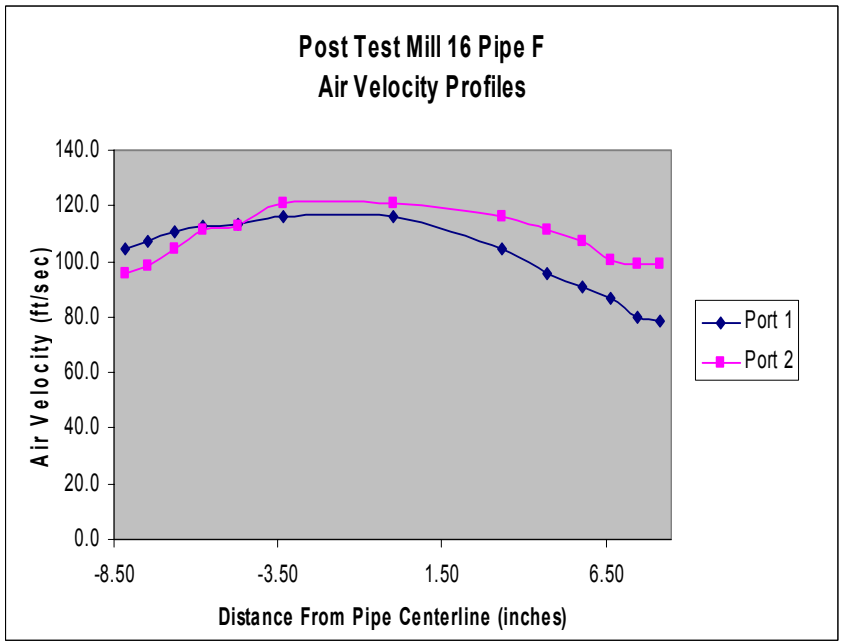

Pre Test Mill 16 Pipe C
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2

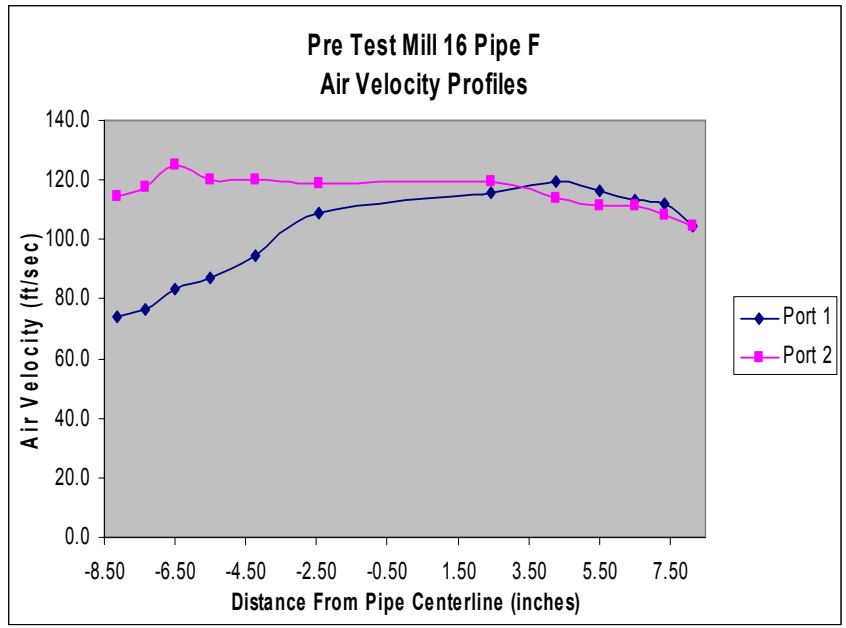

Post Test Mill 16 Pipe D
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2


Pre Test Mill 16 Pipe D
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-6.50
-4.50
-2.50
-0.50
1.50
3.50
5.50
7.50
Distance From Pipe Centerline (inches)
Port 1
Port 2


Post Test Mill 16 Pipe E
Air Velocity Profiles
Air Velocity (ft/sec)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2


Pre Test Mill 16 Pipe E
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-6.50
-4.50
-2.50
-0.50
1.50
3.50
5.50
7.50
Distance From Pipe Centerline (inches)
Port 1
Port 2


Post Test Mill 16 Pipe F
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-3.50
1.50
6.50
Distance From Pipe Centerline (inches)
Port 1
Port 2


Pre Test Mill 16 Pipe F
Air Velocity Profiles
Air Velocity (ft/sec)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-8.50
-6.50
-4.50
-2.50
-0.50
1.50
3.50
5.50
7.50
Distance From Pipe Centerline (inches)
Port 1
Port 2